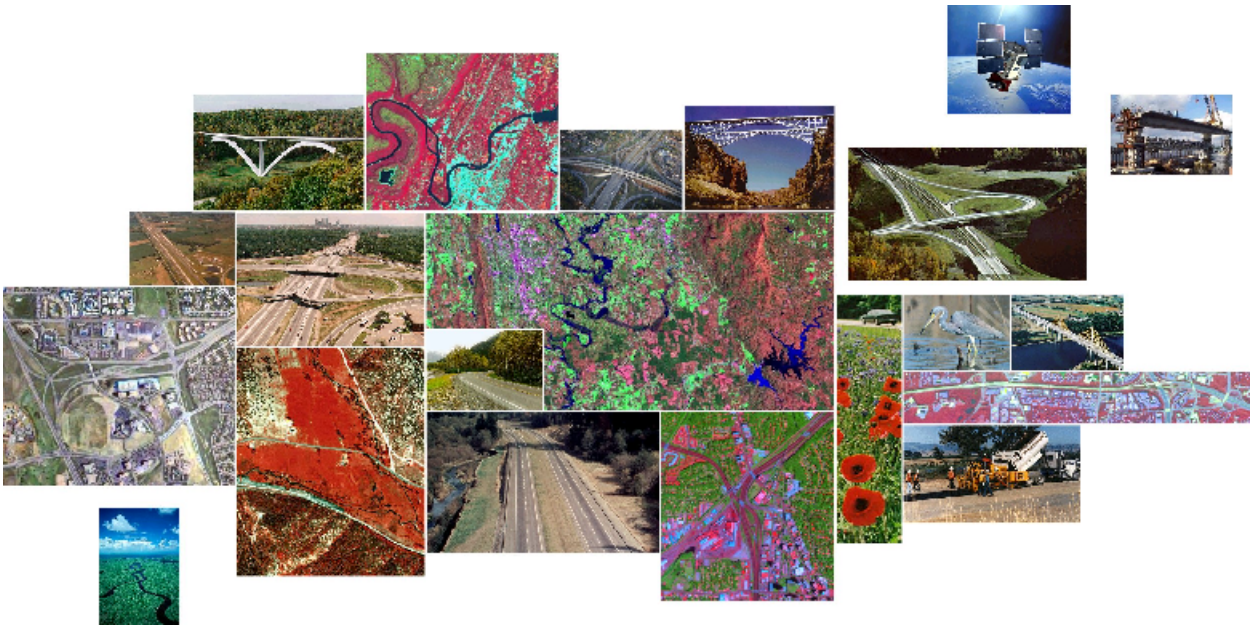
NCRST-E National Consortium for Remote Sensing in Transportation - Environmental Assessment

TECHNOLOGY GUIDE: NCRSTE_TG001

Assessing the Need for Remote Sensing Information to Conduct Environmental Assessment in Transportation



December 2001

Prepared by
C. Laymon, J. Cruise, M. Estes, B. Howell
National Space Science and Technology Center
Global Hydrology and Climate Center
320 Sparkman Dr.
Huntsville, AL 35805

Forward

The U.S. Department of Transportation established four consortia for the purpose of identifying ways of applying remote sensing in transportation. The National Academy of Sciences Transportation Research Board hosted a workshop in December, 2000 to publicize the establishment of the four consortia and to obtain input from potential stakeholders associated with Federal, State and local governments as to their geospatial information needs. The result was a broad array of needs requiring one-time and reoccurring assessment. This document is a synthesis of material from many sources and includes the information gathered at that initial workshop as well as additional information from literature review and surveys of transportation and environmental professionals from industry, academia, and the government.

This is a working document. As the subject matter is very broad, this document is the results of a fairly limited survey of a cross-section of professionals in the environmental assessment and transportation industry. We feel that it is important to collect input from a broader sample of industry professionals. This document, therefore, will be circulated for a period of time and we encourage feedback from a broader community of remote sensing professionals, image analysts and stakeholders. The document is available electronically at http://www.ncrste.msstate.edu/publications/ncrste_tg001.pdf. Please email me any comments you might have regarding the text or regarding any experiences you have had in remote sensing applications in transportation.

This document is primarily intended to serve the scientists within the NCRST-Environmental Assessment as an aid in focusing efforts by prioritizing the needs of the transportation industry for assessment information. However, the remote sensing community at large may be served by identifying application areas and potential markets. This document may also serve stakeholders as an initial overview of areas where they may expect to see additional geospatial information technologies come available in the very near future.

On behalf of the consortium, I would like to personally thank Peter Liao and Steve Just of Research Triangle Institute, Research Triangle Park, NC for their contributions to this report. Peter and Steve acquired information through telephone surveys with environmental and transportation professionals. Additional research with environmental professionals and literature search was conducted by consortium personnel.

Charles Laymon
charles.laymon@msfc.nasa.gov

Executive Summary

One of the strategic goals of the Federal Highway Administration (FHWA) is to "protect and enhance communities and the natural environment affected by transportation." Environmental protection is accomplished through Environmental Assessments and Environmental Impact Statements (EIS) that seek to prevent adverse environmental effects from taking place rather than mitigating problems caused by past activities or practices. EISs are conducted in the context of an overall decision-making process that is inexact and fluid. Despite the fact that EISs are conducted in accordance with Executive Orders, environmental laws, and regulations, the process is laced with subjective components, such as "significant impact," "best available data," and loosely defined accuracy requirements. Although the rationale for EISs is environmental protection, they are not in and of themselves regulatory. The cost to the environment is weighed against the benefits of the proposed project. EISs are simply a source of information on which to base informed decisions.

For the most part, there are no hard and fast rules or requirements in EIS preparation. The laws and regulations tend to address the process, not specific procedures. The courts have determined that the best method does not even have to be used. The information used, however, should have sufficient scientific and analytical substance to provide a basis for comparing alternatives, and should contain sufficient supporting information or results of analyses to establish the reasonableness of the conclusions on impacts. Decisions regarding the adequacy of certain data or methods are up to the discretion of the engineer overseeing the assessment.

Although the data issue is a very small part of an overall streamlining effort, the U.S. Department of Transportation seeks to determine if remote sensing can contribute to streamlining the environmental assessment process. The framework noted above contains significant latitude for the application of remote sensing as a supplemental or alternative source of environmental information associated with transportation development. Of the 25 environmental impact areas the FHWA recommends addressing in an EIS, 13 are good candidates for remote sensing in some capacity. In many cases, current "off-the-shelf" techniques can be utilized directly. In other cases, the assessment requirements dictate using newer data sets for which experience is limited or for which image processing techniques need to be refined or developed. However, these issues do not appear to be insurmountable obstacles.

Perhaps the greatest challenge is in obtaining broad utilization and acceptance of remotely sensed imagery. Skepticism, unfamiliarity, cost, capital equipment and human resource needs are just of few of the anticipated impediments that must be addressed before broad utilization and acceptance can be achieved. In some cases, these impediments are real and substantial, but in many instances, they are fairly trivial. The NCRST-E is appropriately postured to provide the research and development and outreach services needed to raise remote sensing to the forefront of environmental assessment in transportation. The lessons learned over the last fifteen years with the implementation of GIS and GPS technology in transportation planning and engineering should be applied to remote sensing technology as well. A broad array of demonstration projects are needed, not simply to provide examples of remote sensing capabilities, but to engage the stakeholders in the process, assess the costs and benefits relative to performance indicators, and demonstrate overall the intrinsic value in accepting change.

Table of Contents

Introduction

The National Environmental Policy Act of 1969 (NEPA) (42 USC § 4321, http://www.fhwa.dot.gov/environment/nepatxt.htm) marked the beginning of the environmental review process for all federal actions. The intent of NEPA is to ensure informed decision-making pertaining to environmental management by requiring the federal government to use all practical means and measures to create and maintain conditions under which people and nature exist in harmony. Under NEPA, applicable projects are assessed in relation to the environmental conditions of the area, and the impact that various project alternatives would have upon those environmental conditions.

Federal Highway Act of 1970 placed responsibility on the U.S. Department of Transportation (US DOT) Federal Highway Administration (FHWA) to fully consider adverse effects of transportation on community cohesion; public facilities; employment; tax and property values; displacement of people, businesses, and farms; and community and regional growth. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires transportation interests to recognize environmental values and incorporate environmental protection and enhancement measures into programs to develop and improve the nation's surface transportation system. In response to ISTEA, FHWA broadened its mission to reflect increasing interest throughout the nation in developing an environmentally sensitive transportation system. The renewed emphasis on the environmental and community impacts of transportation changed the framework of transportation planning and decision-making and vastly expanded the number of stakeholders who have an active interest in the FHWA's programs and policies.

There is a pervasive perception that the environmental process results in extensive delays and additional costs in completing transportation projects. In a recent study, the FHWA concluded that the NEPA process accounted for approximately 28% of the overall time for project development (FHWA, 2001). In addition, the study concluded that the length of time to prepare and complete Environmental Impact Statements (EISs) was increasing from an average of two years in the 1970's to five years in the 1990's. NEPA, however, is not the sole source of delays as additional laws and regulations, which have their own special requirements, are required and addressed concurrently with the NEPA process. Additionally, various permits may be required if particular environmental factors are present. Although these are initiated during the NEPA process, they are generally not completed until after NEPA has been completed due to the greater level of detail needed to complete the permit applications compared to NEPA documents. Reviews by various federal, state and local regulatory agencies, and public or private opposition add to further delays (FHWA, 2001).

Given widespread concerns about delays, duplication of effort, and additional costs associated with NEPA and other environmental review processes, under the heading of "Environmental Streamlining," Section 1309 of the Transportation Equity Act for the 21st Century (TEA-21, http://www.fhwa.dot.gov/tea21/) enacted in 1998 directed the US DOT to develop and implement a coordinated review process for construction projects. This review process applies to projects that require environmental assessments under NEPA, or any other environmental review, analysis, opinion, or issuance of an environmental permit, license, or approval by operation of federal law. In response to TEA-21, seven federal agencies signed a National Memorandum of Understanding in 1999 to establish goals, performance measures, and

benchmarks to evaluate transportation and environmental decision-making as part of the effort to reduce project delays.

In May 1999, the US DOT, in cooperation with the National Aeronautics and Space Administration (NASA), sponsored a National Forum on Remote Sensing Applications in Transportation (Brecher, 1999; http://scitech.dot.gov/reeng/sensmsrm/rmtsense/sbrsmstr.html). The Forum was in response to Section 5113 of TEA-21, which requires the US DOT to develop a national policy for use of remote sensing and geospatial information technologies in transportation, and to establish a remote sensing applications program in the context of streamlining (http://scitech.dot.gov/reeng/sensmsrm/rmtsense/rmtsense.html). The Forum convened representative stakeholders in transportation, spatial imaging, and information services. Strategies were explored to facilitate the rapid and large scale application of satellite remote sensing and geographic information system (GIS) technologies to a broad range of transportation issues. The Forum characterized the state-of-the-art in space-based imaging, related information products and services, as well as provided an exchange of ideas on national policy and research priorities. Five transportation priority areas with high payoff potential from remote sensing applications were identified: transportation planning, environmental impact assessment, hazard and disaster response and recovery, infrastructure management, and flow assessments (Brecher, 1999). In a follow-up workshop in August 1999, these priority areas served as the basis for a research framework for developing technology and applications focusing on commercial remote sensing products that can be implemented in transportation practices (http://www.cfm.ohio-state.edu/info/summary.html). This framework then became the basis for a Broad Agency Announcement from the US DOT to establish university consortia to serve as leads in developing these applications (http://www.rspa.dot.gov/0004_sections.html).

One of these consortia, the National Consortia for Remote Sensing in Transportation--Environmental Assessment (NCRST-E; http://www.ncrste.msstate.edu/) has as it primary mission to develop and promote the use of remote sensing and geospatial technologies, and requisite analysis products by transportation decision-makers and environmental assessment professionals to measure, monitor, and assess environmental conditions in relation to transportation infrastructure. To accomplish this mission, the Consortia has four goals:

1. increasing the awareness and understanding of remote sensing technology,
2. developing innovative remote sensing technology solutions for use in transportation assessment and planning, in particular the capabilities of new high resolution, multispectral instruments,
3. developing the tools necessary to extract information content from remote observations in an efficient manner, and
4. streamlining and standardizing data processing for information necessary to meet NEPA environmental assessment requirements.

In order to determine potential applications of remote sensing as a source of measurements, however, we must carefully examine the context in which these measurements are applied. The context is comprised of environmental laws, the agencies that provide guidance in interpreting these laws, and the agencies that regulate and enforce the laws. Inclusion of remote sensing measurements in the environmental assessment process requires some understanding of the responsibilities and organizational structure of agencies involved and the information from remote sensing must be in some way "better" than traditional sources of information before it will be embraced by planners, decision-makers, and other members of the transportation community.

The objective of this Technical Guide is to characterize the framework of laws, regulatory agencies, and procedures within which environmental assessment in transportation is executed, to provide an overview of the information required to conduct an environmental assessment, and to identify areas where remote sensing has the greatest potential as a supplemental source of geospatial information. This document is divided into two parts. In the first part, we characterize the framework in which environmental assessment is conducted, and in the second part, we address what information is required for environmental assessments in transportation and initiate discussion as to how remote sensing can contribute to this process.

PART I

The EIS Framework

National Environmental Policy

History of Environmental Management

Environmental laws first appeared in the U.S. in the late 1800's. Established in 1872, Yellowstone National Park was the first national park to protect a large tract of land from denudation and pollution. In 1899, the Rivers and Harbors Act made it illegal to dump material into the nation's waterways without a permit from the Army Corps of Engineers. The Wildlife Restoration Act of 1937 invoked protection and management of wildlife habitat. Following the world wars, economic development was not hampered by environmental laws. By the 1960's, the environment, particularly that of the western U.S., was being exploited for economic gains. These and many other scrupulous environmental practices were significantly curbed with the National Environmental Policy Act of 1969.

In the wake of NEPA, came a flood of environmental laws and government reform. The 1970's became known as the "environmental decade." Congress passed the Clean Air Act in 1970 and the Water Pollution Control Act in 1972 to protect drinking water. Other laws regulated strip mining, coal leasing on federal lands, deep-water ports, liquefied natural gas terminals and gas pipelines, solid waste recovery, insecticide and fungicide use, etc. The Endangered Species Act and the Marine Mammal Protection Act made the survival of life forms a national goal of highest priority (Knight, 1980). The Environmental Protection Agency was created in the early 1970's to manage the environmental regulatory programs of the federal government. By the end of the decade, the EPA was the largest regulatory agency and regulated the largest government public works program, the water pollution control program. Philosophies changed as to how to manage natural resources. Protection for federal lands was expanded and enhanced. New categories of protected lands were created and entire ecosystems were protected in Alaska. Mining and predator control practices changed. Off-road vehicle use was limited. Financial incentives were invoked for states that developed plans for the use and protection of their coastal lands (Knight, 1980). To this day, environmental management and economic progress are often at conflict. Environmental management and protection are implemented for the long-term and the benefit of all present and future citizens, whereas development and "progress" are typically for short-term benefit and often serve a smaller group of citizens.

> *NEPA requires the Federal Government to use all practicable means and measures to create and maintain conditions under which people and nature exist in harmony.*

NEPA

The purpose of the National Environmental Policy Act is to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts that will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality (CEQ). NEPA makes it clear that it is the responsibility of the federal government to use all practicable means consistent with national policy to ensure that the Nation may:

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

2. ensure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
3. attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
4. preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;
5. achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and
6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Towards this purpose, the NEPA mandate compels informed decision-making by federal agencies and their departments by requiring consideration of all relevant environmental consequences of proposed actions and involving the public in the decision-making process.

The CEQ created by NEPA established detailed requirements for agencies to consider environmental impacts in their decision-making process (Regulations for Implementing the Procedural Provisions of the National Environ-mental Policy Act, 40 CFR 1500-1508, 1986). CEQ regulations provide the basic framework for Environmental Impact Statement regulations and the procedural requirements for compliance with NEPA. However, since the regulations were written for all federal agencies, which have a variety of responsibilities, they are necessarily broad and in some cases vague (Kreske, 1996). CEQ has also issued several nonregulatory guidance publications on NEPA: Questions and Answers about the NEPA Regulations (1981), Scoping Guidance (1981), and Guidance Regarding NEPA Regulations (1983).

Environmental Policy of the Federal Highway Administration

FHWA's Mission

The Federal Highway Act of 1970 places responsibility on the Federal Highway Administration to fully consider adverse effects of transportation on community cohesion; public facilities; employment; tax and property values; displacement of people, businesses, and farms; and community and regional growth. The FHWA's mission is to continually improve the quality of our nation's highway system and intermodal connections. One of its five strategic goals, is to carry out its mission in a manner that protects and enhances the natural environment and communities affected by transportation. Protecting and enhancing the environment affected by transportation requires that principles of environmental stewardship be incorporated in all of the FHWA's policies, procedures, and decisions. This means that the FHWA responsibly considers and evaluates all aspects of the environment throughout the highway planning, design, and development process. Beyond environmental stewardship, the FHWA must demonstrate leadership on environmental matters with state and local agencies that implement transportation projects and programs throughout the country.

FHWA's Role in Environmental Research

Accomplishments of the FHWA in environmental matters of the past decade are summarized on the FHWA web site (http://www.fhwa.dot.gov/environment/accomp/toc_intro.htm). Over the years, the role of the FHWA evolved and the agency expanded its mission beyond that of

constructing a nationwide transportation system. In 1987, the FHWA's Office of Environmental Policy issued "Guidance for Preparing and Processing Environmental and Section 4(f) Documents" (T6640.8A, http://www.fhwa.dot.gov/environment/nepa/ta6640.htm) This document is still the principle authority on environmental assessment today. The FHWA's Environmental Policy Statements of 1990 and 1994 established the Environmental Research Program (ERP) and launched a renewed commitment to environmental protection (http://www.fhwa.dot.gov/environment/nepa/epsfinal.htm). This was largely the result of a national conference in 1991 during which a transportation-related program of needed environmental research was formulated (TRB Circular 386).

During the 1990s, the FHWA's role broadened to reflect increasing interest throughout the nation in developing an environmentally sensitive transportation system. This shift occurred for several reasons. The most important were the enactment of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21) in 1998. In enacting ISTEA and TEA-21, the U.S. Congress emphasized the need for an integrated and multimodal transportation system that reflects environmental sensitivity and community values. "Environment" now included the natural environment, the built environment, the cultural and social fabric of our country and our neighborhoods, and the quality of life of the people who live there. The renewed emphasis on the environmental and community impacts of transportation changed the framework of transportation planning and decision-making and vastly expanded the number of stakeholders who have an active interest in the FHWA's programs and policies. In 1996, another conference was held and identified transportation environmental research needs in 13 topic areas (TRB Circular 469, http://itre.ncsu.edu/A1F02/toc_envneeds.html).

Since 1990, environmental research at the FHWA has been supported and managed by the Planning and Environment Core Business Unit (formerly the Office of Environment and Planning). Through the coordinated activities of the ERP, tools are developed that increase our understanding of how transportation facilities interact with the environment. The ERP provides updated or state-of-the-art technologies, analytical methods, and predictive models that can be used to make sound transportation decisions, and that reflect sensitivity to environmental and human needs. The FHWA ERP conducts and supports research related to the design, planning, construction, operation, and maintenance of transportation systems and their impacts on the human and natural environments. The research conducted during the past decade reflects the changing needs and interests of their stakeholders and customers. The research activities of the ERP are designed to provide the most effective and efficient transportation systems possible, while simultaneously protecting, preserving, and enhancing all elements of our environment.

The FHWA collaborates with other federal agencies, state and local transportation and environmental agencies, academic institutions, and private organizations to conduct or support research. It also manages programs and activities that encourage such collaboration. One such program is the Transportation Environmental Research Program (TERP), which focuses on colleges and universities to encourage environmental research related to transportation (http://www.fhwa.dot.gov/terp). TERP began in 1997 to provide start-up funding for university research in environmental areas, such as air quality, wetlands, climate change, environmental justice, community impact assessment, historic and archaeological preservation, and many other transportation-related areas. Through TERP, the FHWA hopes to better understand the complex relationships between transportation and the environment. A major benefit of the TERP is the

opportunity it creates for students and faculty at colleges and universities to directly participate in the FHWA research program and to contribute by providing solutions to our research needs. The TERP also helps us increase the pool of potential researchers in the fields of transportation and environment so that they can continue to support environmentally sound decisions throughout all phases of highway development.

In 1998, the FHWA published a brochure entitled "Environmental Research--Linking Transportation, the Environment, and the Future" that highlights 14 exemplary FHWA and State Departments of Transportation projects across America that are meeting the environmental research challenge. Also in 1998, FHWA published a Strategic Plan for Environmental Research (1998-2003) that summarizes the key environmental research goals of the FHWA's Office of Planning, Environment, and Real Estate Services (http://www.fhwa.dot.gov/environment/env_resh.htm). One of its strategic goals is to "protect and enhance communities and the natural environment affected by transportation." The plan includes research goals for natural environment, human environment, and integrated decision-making focus areas in support of the FHWA Strategic Plan. Implementation strategies are also presented, including coordination and partnership, dissemination and outreach, and performance evaluation. Evaluation of the effectiveness of the ERP will help to ensure that the goals and objectives of the program are achieved (http://www.fhwa.dot.gov/environment/straplan.pdf).

Environmental Assessment

The terms "environmental assessment" (EA), "environmental impact assessment" and "environmental impact statement" are often used interchangeably to refer to the analysis of environmental impacts. An EA or EIS is both a process and the document that results from the process. An EA is prepared for proposed actions when it is not known *a priori* whether the proposal would result in significant impacts to the environment. An EIS is part of a decision-making process at the planning stage of a project involving numerous "players" that have a wide range of responsibilities. The process requires us to take a hard look at the consequences of our actions on the environment. Because of the worldwide trend toward depleting resources and allowing unchecked pollution, Congress enacted environmental laws. The EIS process is part of governmental planning and is affected by environmental laws, such as the Endangered Species Act, the National Historic Preservation Act, the Clean Water Act, etc. The EIS process is forward-looking and seeks to prevent adverse environmental effects from taking place rather than mitigating problems caused by past activities or practices. The EIS process weighs the cost to the environment (not necessarily in dollars) against the benefits of the proposed project.

EIS's have been produced since the early 1970's on virtually every type of federal activity, from oil and gas development to scientific research in Antarctica, and from protection of wildlife habitat to construction of light rail lines. One of the world's largest collections of environmental impact statements is available at the Transportation Library of Northwestern University (http://www.library.northwestern.edu/transportation/searcheis.html). Nearly all of the EIS's issued by federal agencies are held at this library, in draft and final form, as well as related documents, such as environmental assessments, findings of no significant impact, records of decisions, supplementary reports, and maps. The collection is updated with weekly shipments from the Environmental Protection Agency. EIS's are also listed on the EPA Office of Federal Activity's web site by date of distribution (http://www.epa.gov/oeca/ofa).

The EIS Framework

Planning and Environmental Regulations

Laws and regulations that control environmental activities can be broadly categorized as those that control land use (including air and water), the use of natural resources, and pollution. Regulatory planning usually affects the disposition of land or natural resources for a given area under an agencies jurisdiction as part of a management plan. These plans govern land use and control development or other activities imposed on the land. Historically, planners were primarily concerned with the orderly development of towns and cities. Today, planning is very multifaceted through consideration of a wider variety of issues thereby requiring the EIS process to be very interdisciplinary. Planning takes place at all levels of government. Thus, the evaluation of a proposed project's consistency with plans and policies of agencies with jurisdiction over the project could crosscut multiple plans.

An EIS serves as an evaluation of whether a proposed project is consistent with the objectives of the regulatory agency whose responsibility it is to manage the resource. In project-specific planning, an EIS serves as an evaluation of the environmental consequences of a proposed action. Inconsistencies between plans and policies are disclosed in an EIS, but it is more beneficial if the inconsistencies are resolved. The EIS, therefore, provides motivation for dialogue among interested parties. EISs are prepared early in the planning process, so that modifications can be made to the project based on findings resulting from the assessment phase that would reduce the impacts of the proposed action to the point where further modifications would become difficult to accommodate. Most proposals that require an EIS are fairly large and complex and require multiple approvals and refinements before the planning is final. After an EIS is completed, the proposed project continues to be evaluated throughout the rest of the planning phase. Late in the process, the project has usually undergone considerable modification and evolved into a more mature design that reflects public input and regulatory modifications.

Compliance with regulations does not take place via the EIS. The only law an EIS complies with is NEPA or comparable state laws.

The President of the United States issues executive orders, some of which relate to environmental protection (Table 1). Tables 1 and 2 list some of the environmental statues commonly addressed by EISs. An EIS discloses the laws and regulations that are applicable to a proposed action, and states whether and to what degree a proposed action would comply with these laws. Compliance with regulations does not take place via the EIS. The only law an EIS complies with is NEPA or a comparable state law (a SEPA). Environmental regulations are written broadly because they apply to a wide range of agencies. Thus, they provide agencies wide latitude in their EIS methodologies and processes. Most agencies with EIS responsibilities have detailed EIS procedures. Since 1970, guidelines and regulations have provided the basic requirements for preparation of an EIS, but a great deal of flexibility, as well as ambiguity, is also in the regulations. The courts have provided interpretations of the regulations, clarifying some parts while leaving other parts ambiguous. In some cases the courts have made conflicting decisions. Thus, over the course of the last 25 years, individuals who have managed and prepared EISs have developed their own style and method of EIS preparation that work best for them (Kreske, 1996).

Table 1: Presidential Executive Orders Pertaining to Environmental Protection

				Federal Register Cite	
Number	**Date**	**Title**	**President**	**Vol.**	**Page**
11514	5 May 70	Protection and Enhancement of Environmental Quality	Nixon	35	4247
11593	13 May 71	Protection and Enhancement of the Cultural Environment	Nixon	36	8921
11644	8 Feb 72	Use of Off-Road Vehicles on Public Lands	Nixon	37	2877
11967	24 May 77	Exotic Organisms	Carter	42	26949
11988	24 May 77	Flood Plain Management	Carter	42	26951
11989	24 May 77	Off-Road Vehicles on Public Lands (amends 11644 above)	Carter	42	26959
11990	24 May 77	Protection of Wetlands	Carter	42	26961
11991	24 May 77	Protection and Enhancement of Environmental Quality (amends11514 above)	Carter	42	26967
12088	13 Oct 78	Federal Compliance with Pollution Control Standards	Carter	43	47707
12114	4 Jan 79	Environmental Effects Abroad of Major Federal Actions	Carter	44	1957
12148	20 Jul 79	Federal Emergency Management (amends 11988 above)	Carter	44	43239
12316	14 Aug 81	Responses to Environmental Damage	Reagan	46	42237
12580	23 Jan 87	Superfund Implementation (amends 12088 above)	Reagan	52	2923
12898	11 Feb 94	Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Clinton	59	7629

Source: Modified from Joseph A. Wellington, A Primer on Environmental Law for the Naval Services, *Naval Law Review*, 1989.

Table 2: Federal Pollution Control Statutes

Statute	**Concern**	**Acronym**
Federal Water Pollution Control Act Amendments of 1972 (Clear Water Act)	Water pollution including filling wetland	FWPCA (CWA)
Marine Protection, Research, and Sanctuaries Act of 1972 (Ocean Dumping Act)	Ocean dumping of wastes/dredge material	MPRSA
Clean Air Act Amendments of 1970	Air pollution	CAA
Noise Control Act of 1972	Noise pollution	NCA
Federal Insecticide, Fungicide and Rodenticide Act of 1947	Pesticide pollution	FIFRA
Federal Environmental Pesticide Control Act of 1972	Pesticide pollution	FEPCA
Resource Conservation and Recovery Act of 1976	Hazardous and nonhazardous waste management	RCRA
Toxic Substances Control Act of 1976	Chemical substances control	TSCA
Rivers and Harbors Act of 1899	Deposition of refuse (Section 13) in navigable waters	RHA
Comprehensive Environmental Response, Compensation and Liability Act of 1980	Contain and clean up releases of hazardous substances	CERCLA
Superfund Amendment and Reauthorization Act of 1986	Cleanup of contamination from past hazardous waste disposal	SARA

Sources: Modified from Joseph A. Wellington, A Primer on Environmental Law for the Naval Services, *Naval Law Review*, 1989 and *Naval Readiness, Operational Training and Environmental protection: Achieving an Appropriate Balance Between Competing National Interests* (unpublished), June 1988.

Agencies with EIS Responsibilities

Environmental statues and executive orders are applicable to all federal agencies; however, certain agencies have a primary, or oversight role to ensure compliance by other agencies and private parties (Table 3). Agencies that most frequently deal with EIS processes are those that have planning and environmental responsibilities, such as land and natural resource management agencies, agencies involved in construction, permitting and licensing, and those that are a source of funding. Agencies that manage land or natural resources include agencies at the federal level, such as the Bureau of Land Management, U.S. Forest Service, National Park Service, American Indian tribes, and the military branches. Agencies involved in construction include the Army Corps of Engineers, Bureau of Reclamation, and the U.S. Department of Transportation. Agencies that issue permits and licenses subject to NEPA review include the land management agencies, U.S. Army Corps of Engineers, U.S. Coast Guard, and the Federal Energy Regulatory Commission. Agencies that provide funds include the Department of Transportation, Department of Housing and Urban Development, Economic Development Agency, and Federal Housing Administration. Although agencies with similar responsibilities comply with the same environmental laws, the internal policies and procedures for a particular environmental concern may differ from agency to agency.

In order to define the stakeholders for remote sensing information, it is necessary to know the purpose and responsibilities of various agencies involved in the EIS process. Several key "players" associated with environ-mental regulation and/or transportation are noted as follows (The United States Government Manual 1994/95; Kreske, 1996):

The President—The President is constitutionally charged with ensuring the execution of the Nation's laws and issues executive orders, including those pertaining to the environment.

Council on Environmental Quality—The CEQ consists of three members appointed by the President that report directly to him. The Council was established by NEPA to oversee its implementation (see Council on Environ-mental Quality Regulations on Implementing NEPA, 40 CFR 1500-1508), and develops and recommends to the President national policies that further environmental quality, performs a continuing analysis of changes to trends in the national environment, appraises programs of the federal government to determine their contributions to sound environmental policy, and assists the President in the preparation of an annual environmental quality report to Congress. The CEQ is not a full regulatory body because it can neither veto nor control another agency's projects. Presidential Executive Orders (11514 and 11991) authorized the CEQ to issue regulations governing the EIS process. Thus, CEQ regulations provide the basic framework for EIS regulations and the procedural requirements for compliance with NEPA. The regulations also required that federal agencies develop their own regulations to ensure that the agencies' decisions are made in accordance with the policies and purposes of the act. Consequently, agencies at the federal, state, and local levels have internal procedures, regulations, or ordinances that may have specific requirements that go beyond NEPA.

Department of Transportation—The US DOT establishes the Nation's overall transportation policy. It oversees ten administrations dealing with planning, development, and construction of road, rail, air, and water transportation systems. The aviation, highway, and rail administrations are described below.

Table 3: Federal Environmental Protection Oversight Agencies

Type	Statute	Oversight Agencies
Resource protection/land use control	NEPA	CEQ (EIS process), and EPA (EIS review and classification) ACHP, NPS
	NHPA	Federal Land Manager[a]
	ARPA	NOAA (permits)
	MPRSA	USFWS, NMFS[b]
	MMPA	ESC (exemptions)[c]
	ESA	USFWS, NMFS (biological opinions) NOAA
	CZMA	
Pollution control	FWPCA (CWA)	EPA (NPDES permit)[d] COE (dredge/fill permit)
	RHA	COE (obstructions and disposal permits)
	MPRSA	EPA (non-dredge waste dumping permit) COE (dredge material dumping permit) USCG (surveillance of dumping)
	CAA	EPA (permit)
	NCA	EPA
	FIFRA	EPA
	RCRA	EPA (permits, identification numbers)
Environmental restoration	CERCLA	EPA
	SARA	EPA

Key: ACHP, Advisory Council on Historic Preservation; CEQ, Council on Environmental Quality; COE, U.S. Army Corps of Engineers; ESC, Endangered Species Committee; EPA, Environmental Protection Agency; NMFS, National Marine Fisheries Service; NOAA, National Oceanic and Atmospheric Administration; NPS, National Park Service; USCG, U.S. Coast Guard; USFWS, U.S. Fish and Wildlife Service. For statutes, see Tables 1 and 2.

[a]The term "Federal Land Manager" means the Secretary of the Department, or the head of any other agency or instrumentality of the United States having primary management authority over public lands.

[b]The U.S. Fish and Wildlife Service and the National Marine Fisheries Service have jurisdiction over different species of marine mammals. For Example, the USFWS has jurisdiction over polar bears, sea otters, walruses, and manatees, while the NMFS has jurisdiction over whales, porpoises, seals, and sea lions.

[c]The Endangered Species Committee can grant exemptions if necessary (e.g., for reasons of national security.) See 16 U.S.C.S. &1536(j).

[d]An "NPDES" (National Pollutant Discharge Elimination System) permit allows its holders to discharge a certain type/amount of pollutant into the waters of the United States.

Source: Modified from Joseph A. Wellington, A Primer on Environmental Law for the Naval Services, *Naval Law Review*, 1989.

Federal Aviation Administration (FAA)—The FAA is charged with regulating air commerce and its development, controlling airspace of the U.S., developing and operating air traffic control and navigation facilities, and implementing programs and regulations to control aircraft noise, and other environmental effects of civil aviation.

Federal Highway Administration (FHWA)—The FHWA is concerned with the total operation and environment of highway systems. The agency considers the impacts of highway development and travel, transportation needs, engineering and safety aspects, social, economic, and environmental effects, and project costs.

Federal Railroad Administration (FRA)—The FRA promotes and enforces rail safety regulations, administers financial assistance programs, conducts research and development in support of safety and policy, and rehabilitation of rail services.

Environmental Protection Agency (EPA)—The EPA was created to coordinate effective governmental action on behalf of the environment. The objective of the EPA is to control pollution through research, monitoring, establishing standards, and enforcement. The EPA also reinforces efforts among other federal agencies with respect to the impact of their operations on the environment, and is specifically charged with publishing its findings when it is determined that a proposal is unsatisfactory from the standpoint of public health or welfare of environmental quality.

EPA has many responsibilities under several environmental laws. Section 309 of the Clean Air Act gives the EPA specific responsibility to file, review, and rate EISs. Federal EISs are filed with the EPA who then publishes a notice of availability in the Federal Register. The EPA reviews and provides written comments on federal EISs, evaluating the environmental effects of the proposed action and the adequacy of the Draft EIS. Specific procedures are in place defining criteria used by EPA reviewers to determine an appropriate rating for an EIS, procedures for follow-up action with the lead agency, and procedures for distribution of comments (Kreske, 1996). In most cases, the EPA provides detailed comments on the range of alternatives, the methods used in the analyses, and the adequacy of data. The Clean Air Act authorizes the EPA to refer an unsatisfactory EIS or agency action to the CEQ and/or take administrative action under environmental laws over which it has jurisdiction. The EPA may choose to withhold from issuing a permit where one is required or recommend that another permitting agency do the same under that agencies purview.

The EPA reviews federal EISs and evaluates their adequacy.

The EIS Process

Process Participants

Proponents—also known as *Project Applicant,* or *Sponsor*. A project proponent is the agency or private entity, such as a developer or landowner, that requires funding approval, or a permit from another agency (Kreske, 1996). If a permit is necessary for a proposed project, the "*proponent*" applies for a permit and is therefore referred to as the "*applicant*." The primary role of the proponent is to provide information regarding the design, construction, and operation of a proposed action or project. For a new highway project, the proponent would likely be the FHWA.

Lead Agency—The lead agency is responsible for preparation of the EIS and for making a decision on the proposed action. Regardless of whether an EIS is a federal or state document, and regardless of who prepares the document, it is the lead agency who is responsible for its content and conclusions. If someone other than the lead agency prepares an EIS, such as a consulting firm, the lead agency must provide independent review of the document and ensure that it meets the agency's standards. A lead agency may be a federal, state, or local agency with authority to approve, permit, or fund a private proposal and with authority to act as a lead agency in the preparation of EISs. A lead agency makes decisions regarding the EIS's scope (the issues and alternatives analyzed in an EIS), the amount of public involvement, the time allowed for public review of the EIS, the data to be used, the accuracy of the data, and the appropriateness of the level of analysis.

The lead agency makes decisions regarding what data is used and the accuracy required.

EIS team—EISs are prepared by an interdisciplinary team of individuals, such as scientists, engineers, and planners, which may be employees of the lead agency, private consultants, university professors, and agency staff. The required number and type of professionals depends on the range of issues addressed by an EIS. An EIS team consists of professionals with the credentials and experience to analyze the elements of the environment that are within the scope of an EIS. The team members' responsibilities are to provide objective analyses commensurate with the level of significance of a potential environmental impact and within the accepted professional standards. The lead agency and the project proponent also should be members of the team to provide the required guidance.

Public Reviewers—The role of reviewers is to understand the proposed project, provided suggestions for alternative ways to meet the purpose and needs of the project, and critically review a Draft EIS. Lead agencies may choose to have the public more involved in the process than is specifically required by regulations, such as identifying potential alternatives or mitigation measures for significant environmental issues. Public review of an EIS is done by private citizens, agencies having jurisdiction by law or expertise, and those who have specifically requested notification. The public review process is not intended to make decisions based on a vote, but is an opportunity for the public to provide input and express concerns regarding the on-going process so that decision-makers can make better informed decisions.

Overall Process

The principle steps involved in executing an EIS are shown in Figure 1. The process begins when a private individual, an agency, or an organization, proposes an action or a project. At this stage, the proposed action or project usually is conceptual or preliminary in design. The lead agency (federal or state) determines whether the proposal is excluded from the requirements to prepare environmental documents. Actions that normally do not result in significant impacts are afforded "Categorical Exclusions" (federal) or "Categorical Exemptions" (some states) and, therefore, do not require further environmental review. Agencies have lists of actions that are excluded or exempt from environmental documentation if the action clearly would not result in significant impacts. If the proposed project is excluded from further environmental review, the project continues to the planning stage. If, however, a proposal is not excluded from environmental review, the lead agency must determine if the proposed activity will result in significant environmental impact.

The requirement to prepare an EIS hinges on whether a proposed project would result in significant impacts to the environment. This decision is called the "threshold determination". Although "significance" is highly subjective, the CEQ provides some guidance on whether actions would be significant through consideration of “context” and “intensity.” If the lead agency cannot determine whether the proposal would result in significant environmental impact, an Environmental Assessment (EA) is prepared to aid in determining whether any impacts from the proposed action would be significant. The EA may be prepared by the lead agency, a proponent, or a consultant. If an EA is prepared by a proponent or consultant, the lead agency reviews the document for adequacy. If the EA concludes that the proposed project would not result in significant environmental impacts, the lead agency issues a "finding of no significant impact", FONSI (federal), or the equivalent at state level, which is publicly reviewed.

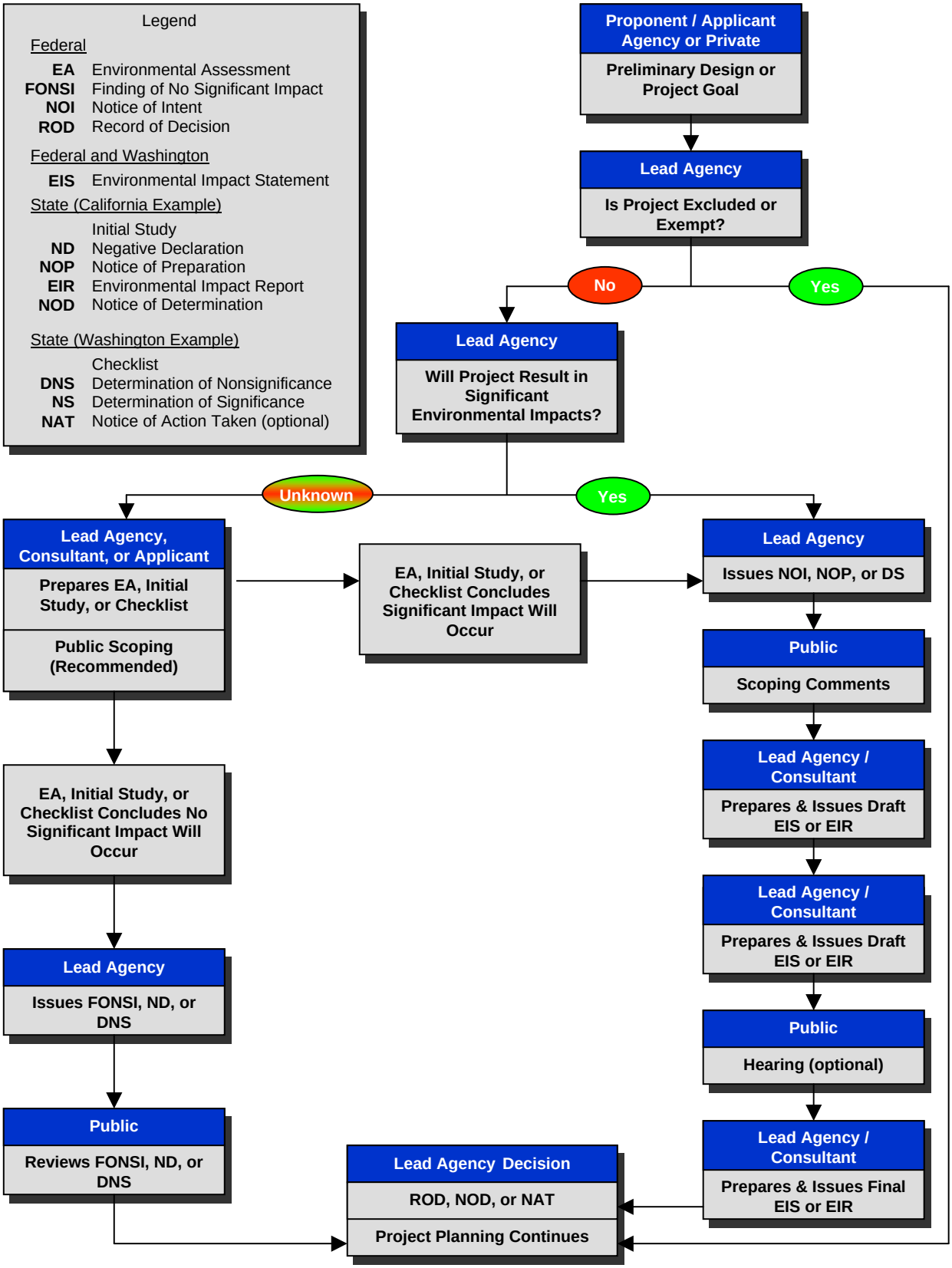


Figure 1: Diagram showing he steps and players in a "typical" environmental review process. Adapted from Kreske, 1996.

If, however, it is determined either before or after the EA that the proposal may result in significant impact, the lead agency publishes in the Federal Register (for federal EISs) a "notice of intent" (NOI) to prepare an EIS and the public scoping process for an EIS is begun. States have similar notification processes. Scoping is the process of collecting and compiling public comments that determine what actions, alternatives, environmental effects, and mitigation measures will be addressed in an EIS. The amount of scoping necessarily varies by agency, the type of environmental review (EA or EIS), and the complexity of the proposed action. Although public scoping is encouraged, many federal and state agencies do not require it for environmental determinations that precede an EIS.

The next major steps involve preparing a Draft EIS and distribution of the Draft EIS for public review. After public review of the Draft EIS, a Final EIS, which responds to comments on the draft document, is then prepared and publicly distributed. The main differences between the basic federal and state processes are in the names of some of the documents and time frames for actions that take place in the process. Depending on the agency jurisdiction for the project location, type of project, and type of approval being sought, the agencies involved in the process and details of procedures will vary.

Effects of EIS Process

An EIS is part of the planning process and is intended to be used to make better informed decisions. Environmental considerations are often overlooked in the day-to-day activities of an organization or company. If we did not take the time to address environmental issues during the planning and design phases of a project, irreversible harm to the environment may result. Failure to address environmental requirements early on can result in project delays and extra costs. This tends to be a principle source of negativity towards environmental requirements.

Streamlining the EIS Process

Because the environmental assessment processes is complex and usually involves many players with different agendas, there is a pervasive perception that the environmental process results in extensive delays and additional costs in completing transportation projects. Part of the problem stems from the fact that the roles and responsibilities of federal, state, and local agencies are often in conflict (Kreske, 1996). Whereas federal and state agencies are responsible for land and natural resource management, local agencies are focused on systematic development and services of private land. Developers and agencies with construction responsibilities struggle with overlapping, duplicate, and conflicting regulations. While CEQ regulations encourage agencies to combine their planning and EIS processes, few agencies have the knowledge or latitude to change their procedures to attempt different approaches. Some agencies, however, are identifying ways to reduce duplicative regulations and streamline by combining some planning and environmental processes.

The FHWA recently conducted a study to determine what proportion of the total project effort was spent addressing environmental issues (FHWA, 2001). The FHWA concluded that while the NEPA process accounted for approximately 28% of the overall time for project development, NEPA was not the sole source of delays. Additional delays resulted from laws and regulations with their own special requirements that are required and addressed concurrently with the NEPA process. Permitting cycles were also found to be out of phase with environmental assessment

processes. Reviews by various federal, state and local regulatory agencies, and public or private opposition add to further delays (FHWA, 2001).

As a result of widespread concerns about delays, duplication of effort, and additional costs associated with NEPA and other environmental review processes, the US DOT, in response to Section 1309 of TEA-21, implemented a coordinated review process for construction projects that require environmental assessment. The goal of this review process is to establish performance measures and benchmarks to evaluate transportation and environmental decision-making for the purpose of reducing project delays. Environmental streamlining is the term used for a new way of doing business that brings together the timely delivery of transportation projects with the protection and enhancement of the environment. Because major transportation projects are affected by dozens of Federal, State, and local environmental requirements administered by a multitude of agencies, improved interagency cooperation is critical to the success of environmental streamlining. Streamlining initiatives have been conducted at the state, regional, and national levels. A memo describing FHWA action on streamlining is available at http://www.fhwa.dot.gov/environment/strmlng/eismemo.pdf and an overview of FHWA stream-lining efforts can be found at http://www.fhwa.dot.gov/environment/strmlng/overview.htm where information is also available about efforts going on at the individual state level.

Preparation of the EIS contributes to the development schedule for a project. Although there is limited information to form a basis, it is generally assumed that greater efficiency in acquiring and analyzing data used in EIS preparation, and better data standards, would reduce EIS preparation time and possibly result in less controversy over the report's findings. EISs are dependent on geospatial information in order to make an assessment. It is felt by many in the transportation industry that high-quality databases that are maintained with current or frequently updated geospatial information would streamline road development projects. Data from remote sensing systems on aircraft or satellite platforms is a potential source of geospatial information. Remote sensing has numerous advantages over traditional data sets. Whether or not remote sensing can be used requires a thorough understanding of what information is needed.

PART II

Information Requirements

Remote Sensing as an Information Source

Whereas geographic information system (GIS) data and aerial photography have been used for environmental assessment of two decades or more, digital imagery from aircraft- and satellite-based sensors is a relatively new source of information to the transportation industry. Remote sensing has been defined as the science (and to some extent art) of acquiring information without actually being in contact with it. Applications of remote sensing information usually fall into one of the following categories:

1. Remote sensing is used as a tool to measure properties or conditions of the land, oceans, atmosphere or objects in space.
2. Images of remotely sensed information serve as base maps on which other information is overlaid for reference and enhanced interpretation.
3. Images of remotely sensed information are used to map and quantify the spatial distribution of features.
4. Multitemporal images can be compared to quantify changes in the area and spatial distribution of features.

Remote sensing has numerous advantages over traditional data sets—it is unobtrusive; one can collect information simultaneously over a broad range of the electromagnetic spectrum; it is capable of making biophysical measurements; information can be acquired through clouds at long wavelengths; data can be collected in a very short timeframe with aircraft platforms and frequently with satellite platforms; data collection procedures are systematic thereby eliminating sampling bias introduced in some investigations; and analysis methods are relatively robust, objective, and repeatable. This is not to say that remotely sensed data necessarily replaces existing data sets, but in many cases it provides supplemental information that can lead to improved assessments. Comprehensive planning required to implement "smart growth" initiatives at local and state levels, road design that uses land cover data and digital terrain models, and emergency management are all enabled by archived and/or current satellite data. Temporal analysis of imagery data allows the calibration of transportation policy alternatives and identification of future trends using modeling.

The extent to which remote sensing can be used for transportation-related assessments requires a thorough understanding of what information is needed. Transportation projects proceed through several phases that require four distinct levels of accuracy: planning, project development and environmental assessment, and construction. The nature of the information required in each phase is quite different. Planning and environmental assessment are transportation priority areas with high payoff potential for remote sensing. The construction phase requires geospatial information of very high accuracy and low tolerances. However, this information is needed to aid actual construction at a point well after environmental assessment of potential impacts has been completed and any mitigations measures necessary have been addressed.

Planning

Planning is based on knowledge about the current state with some prediction as to how the state will change in the future. For long-range transportation planning by Federal, State, or metropolitan planning organizations, the information requirements may be less stringent as the focus is on characterizing general trends. Predicting the future is more precise if it is based on the historical trend projected through the present. The outcome of this process is to obtain a

metric on trends and to steer thinking and planning activities internal to the organization. The accuracy of the prediction depends on the analysis method employed. Linear trends can be defined based on the difference between maps at two points in time. Alternatively, computational models can be employed to define more complex trends as well as the interaction among variables. Generally, however, data used for planning purposes is not required to meet precise accuracy standards.

Environmental or development planning requires geospatial information about the distribution of landscape features. Maps, and to some extent aerial photographs, are the traditional sources of this information. Remote sensing offers tremendous potential for planning purposes because it not only affords a picture of the current state, but unlike aerial photographs, multispectral data can be used to provide information classes, such as land cover and land use. Continuity in temporal classification of land cover and its extension to land use could play a significant role in preparation of a comprehensive development plan and would be invaluable in the planning stage of road development projects.

Data from the Landsat satellite program are invaluable sources of information for regional- and some local-scale planning. The Multispectral Scanner (MSS) on Landsat-1 began collecting data in 1972 and was followed by the Thematic Mapper (TM) on Landsat-4 in 1982 and the Enhanced Thematic Mapper Plus (ETM+) on Landsat-7 in 1999. These instruments have provided a continuous record of the terrestrial globe throughout this period. At 80 m (MSS) and 30 m (TM, ETM+) resolution, it is appropriate that these data only be used to map the distribution of features larger than about 100 m in size. As such, they are quite suitable for mapping natural resource features, such as softwood and hardwood forests, pasture, cropland, residential and industrial areas, water bodies, etc. Unprocessed, "raw" Landsat data going back to 1972 can be purchased over the internet from the U.S. Geological Survey. There are also a number of public domain land cover data products available via the internet. Those produced from Landsat data are available for three "dates" based on images acquired during the 1970's, 1980's, and 1990's. More recent and current land cover data are available on an annual or quarterly basis using multispectral data at 1 km resolution. High resolution commercial remote sensing data at 4 m resolution or less is extremely valuable for local scale planning. Although these data do not show as much detail as aerial photography, their multispectral characteristics can be fused with higher resolution panchromatic data resulting in information classes with high interpretive value.

Environmental Assessment

Never underestimate the power of a picture. Imagery, in general, can aid in informing the public of the proposed action and facilitate engaging the public in the EIS process during the scoping phase. The pre-construction planning, siting, and design phase of any project requiring an EA or EIS is conducted in the context of environmental laws, agencies that provide guidance in interpreting these laws, and agencies that regulate and enforce the laws. Compliance with NEPA or State Environmental Policy Acts (SEPAs) may require preparation of an environmental assessment or environmental impact statement. EISs are prepared early in the planning process and for proposed projects that have the potential to result in significant impacts to the environment. EISs are dependent on geospatial information in order to make an assessment.

There are no rules *per se* as to how to conduct an environmental assessment. The particular objective of each assessment dictates on a case-by-case basis what information and analyses are required. The FHWA, which is responsible for all aspects of the environment pertaining to the Nation's transportation systems, issued its own "Guidance for Preparing and Processing Environmental and Section 4(F) Documents" (FHWA, 1987). The document identifies the expected content of environmental documents. There are no requirements defining how the evaluation must be conducted or what data sets and analyses must be utilized for the assessment. It recommends, however, that "the information should have sufficient scientific and analytical substance to provide a basis for evaluating the comparative merits of the alternatives," and should contain "sufficient supporting information or results of analyses to establish the reasonableness of the conclusions on impacts." The decision about which data sets to use in an assessment is initially left to the discretion of the consulting firm or lead agency that conducts the assessment. Ultimately, in the case of transportation projects, the decision rests with the FHWA, which must approve the EA or EIS. The bulk of the guide comprises a list of 25 areas with "potentially significant impacts most commonly encountered by highway projects." A number of these areas were identified at the December, 2000 Transportation Research Board Conference on Remote Sensing and Geospatial Technologies as high priority areas in need of improved or alternative information sources. Many of these application areas are discussed in some detail below.

The particular objective of each assessment dictates on a case-by-case basis what information and analyses are required.

Land Use Impacts

FHWA Guidelines require that proposed actions be put into the context of current development trends. The EIS must also identify the state and/or local government plans and policies on land use that will be impacted. These plans and policies are normally reflected in the area's comprehensive development plan. The EIS land use discussion should address the consistency of the proposed alternatives with the comprehensive development plans and other plans used in the development of the transportation plan required by Section 134.

Partitioning of spectral information into land cover classes has been a long-standing application of remote sensing with multispectral sensors. Trends are defined with multitemporal geospatial information. Although it is not a trivial task, land cover information can be married with socio-economic information so that it can be translated into land use information. Landsat data at 30 m resolution is suitable for relatively general natural resource classes, such as softwood and hardwood forests, pasture, cropland, residential and industrial areas, water bodies, etc. (Fig. 2.) The U.S. government has funded the Landsat program continually as part of an on-going mapping program and data are relatively very inexpensive. New commercial remote sensing data providers have targeted a market for high resolution multispectral data. These data are therefore better suited for mapping more detailed land cover/land use classes. Unlike Landsat data, commercial data is available through targeted acquisitions, i.e., acquisitions must be scheduled in advance for acquisition on a particular date for a specified area. Consequently, there is no archive of historical data from which to develop trends. Given the newness of commercial remote sensing data, there is still some uncertainty among image analysts who have little experience with these data as to whether existing image processing software has the tools necessary to extract the feature information of interest. Improvements in image analysis techniques may be required to take full advantage of these data.

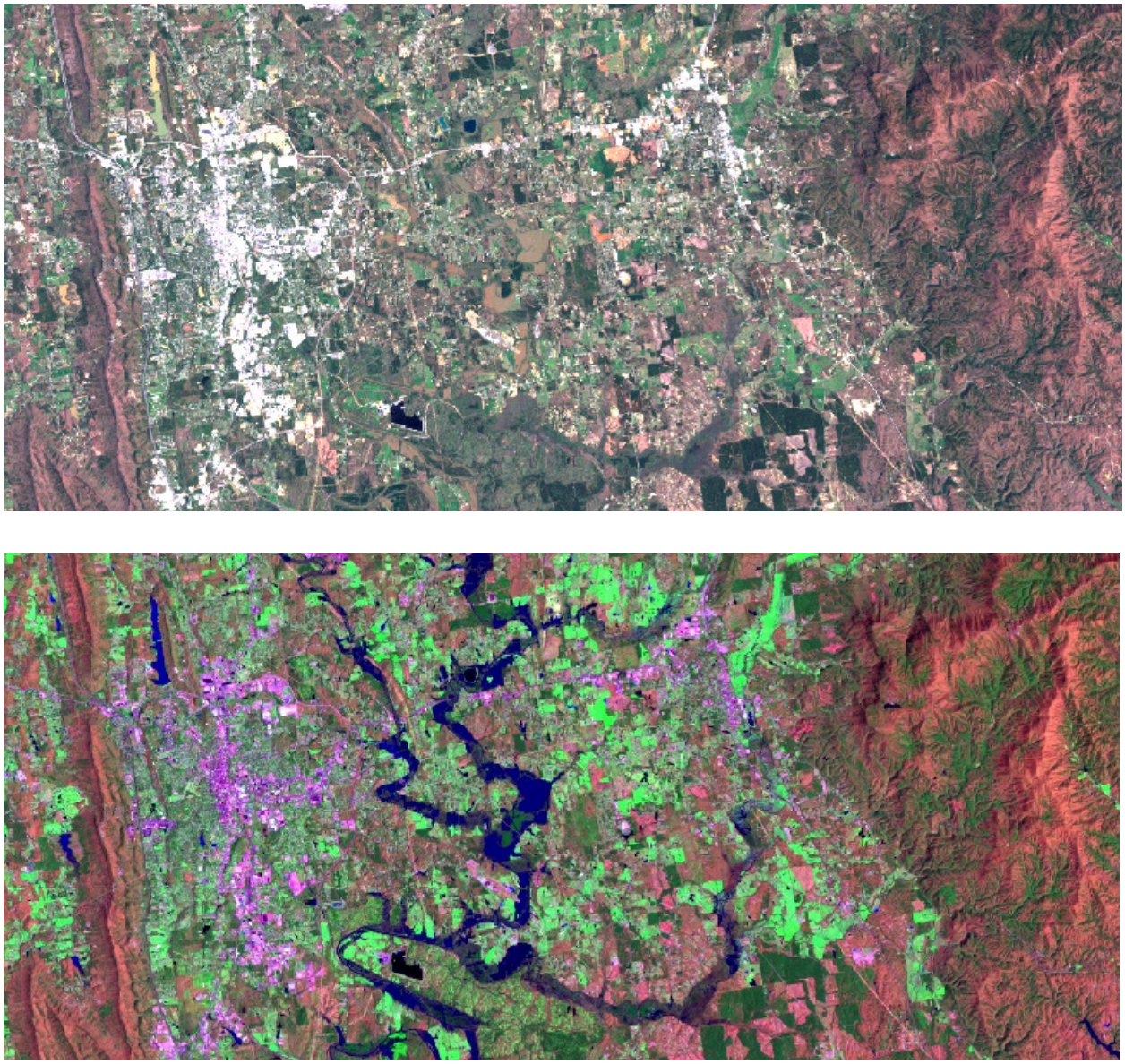


Figure 2: An example of classified land cover information for a region with complex physiography. The top image is a "true color" image similar in appearance as if seen with the naked eye. The land cover of the same region is differentiated into classes in the bottom image for easy quantification and analysis. These data are from Landsat Enhanced Thematic Mapper Plus at 30 m resolution.

The Army Corps of Engineers plans to utilize remote sensing in the Joint Rapid Airfield Construction project that the military intends to implement by 2003. This program seeks to use remotely sensed land cover and digital elevation model (DEM) data for rapid runway development. Remote sensing will be used for rapid site selection, quick assessment of runway stabilization issues, define opportunities to improve existing sites, and for better slope characterization. Other applications of land cover information include characterizing impervious surfaces. The distribution of impervious surfaces is valuable to hydrologic studies and analysis of storm water runoff.

Farmland Impacts

The Farmland Protection Policy Act of 1981 has as its purpose "to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses…" Identifying farmland is partially based on defining what is not farmland by noting areas designated as urban on U.S. Census Bureau maps, U.S. Geological Survey topographic maps, and U.S. Department of Agriculture (USDA) Important Farmland maps or where USDA Natural Resources Conservation Service (NRCS) soil survey maps have designated the area as developed having low farmland potential. Farmland must be characterized as 1. prime, 2. unique, 3. other that is of statewide significance, and 4. other that is of local significance, and EIS preparers are instructed to consult with the NRCS where farmland may be impacted. If farmland may be impacted by a proposed project, the EIS should contain a map showing the location of all impacted farmland, discuss impacts associated with each alternative, and identify avoidance or reduction measures. The characterization of farmland quality is a designation made by the NRCS based on topography, soils, and lack of development. Land use information from classified remote sensing data would be useful in developing maps of the impacted farmland (base map) in relation to adjacent land and proposed alternatives (vector overlays).

Coastal Zone and Barrier Impacts

The Coastal Zone Management Act requires states to develop a Coastal Zone Management Plan approved by the U.S. Department of Commerce to protect coastal zones. Likewise, the Coastal Barriers Resource Act (FWS, 1983; http://www.fhwa.dot.gov/environment/guidebook/vol1/doc2b.pdf) protects coastal barriers. When coastal zones are impacted by proposed projects, the EIS must show evidence that there is coordination with the State Coastal Zone Management agency or appropriate local agency. If the preferred alternative is inconsistent with the Coastal Zone Management Plan, the project can be federally funded only if the Secretary of Commerce determines that the proposed action is consistent with the purpose or objectives of the Coastal Zone Management Act or is necessary in the interest of national security. Where coastal barriers may be impacted by proposed projects, the EIS should include a map showing the relationship of each alternative to the barrier units (FWS, 1983).

Coastal environments are very dynamic and virtually any map is likely to be out of date in a short amount of time. Remote sensing offers the ability to rapidly update maps of the coastal environment with current information and to document the temporal history of coastal dynamics. These same data can provide a base map of current coastal zone configuration upon which management plan information, barrier delineation, and alternatives can be shown.

Floodplain Impacts

The FHWA floodplain encroachment standards were issued in 1979 and are regulated by 23 CFR 650A. The FHWA requires using National Flood Insurance Program (NFIP) maps to determine whether an alternative will encroach on the base (100-yr) floodplain. Three types of NFIP maps are available: a Flood Hazard Boundary Map, a Flood Boundary and Floodway Map, and a Flood Insurance Rate Map (FHWA, 1982a). If NFIP maps are not available for the project area, information developed by the lead agency may be used. This implies that NFIP maps are the standard for floodplain mapping; there is some uncertainty whether this language implies that the

NFIP maps should be used regardless of whether the lead agency can produce more accurate information. Draft EISs should include exhibits of the base floodplain with alternatives. Flooding risk, impacts and efforts to minimize impacts should be defined. Encroachment on a regulated floodway as the only practicable alternative must comply with 23 CFR 650 and Executive Order 11988 (http://www.fhwa.dot.gov/environment/guidebook/vol1/doc6f.pdf). The FHWA recognizes the NFIP standard that provides for up to a 1-foot increase in flood stages when designating a floodway or evaluating an encroachment where no floodway is designated. This standard is established as the Federal standard under Executive Order 11988, Floodplain Management, and is to be used in designating highways in NIFP mapped floodplains (FHWA, 1986a, b). Coordination with FEMA and appropriate state and local government agencies should be undertaken in situations where administrative determinations are needed involving a regulatory floodway or where flood risks in NFIP communities are significantly impacted (FHWA, 1982b). Floodway revision should include evidence from these agencies supporting the revision. Local hydraulic studies are required and usually involving some form of modeling.

Floodplain delineation relies on topographic information. Light Detection and Ranging (LIDAR) and Interferometric Synthetic Aperture Radar (IFSAR) are two relatively new remote sensing technologies that offer an alternative to *in situ* field surveys and photogrammetric techniques for the collection of elevation data (Fig. 3). Although these techniques are relatively complex, they provide timely data with vertical accuracies better than standard topographic maps and comparable to or better than photogrammetric techniques (Flood and Gutelius, 1997). LIDAR and IFSAR are capable of vertical accuracies of about 0.1 to 2.0 m root mean square error. These systems operate from airborne platforms in which Global Positioning Systems (GPS) are an integral part. These data would meet basic requirements for floodplain mapping. A comprehensive Digital Elevation Resource Directory can be found in a recent supplement to Geospatial Solutions and GPS World (Barnes, 2001) and a new text provides a comprehensive guide to DEM technologies (Maune, 2001).

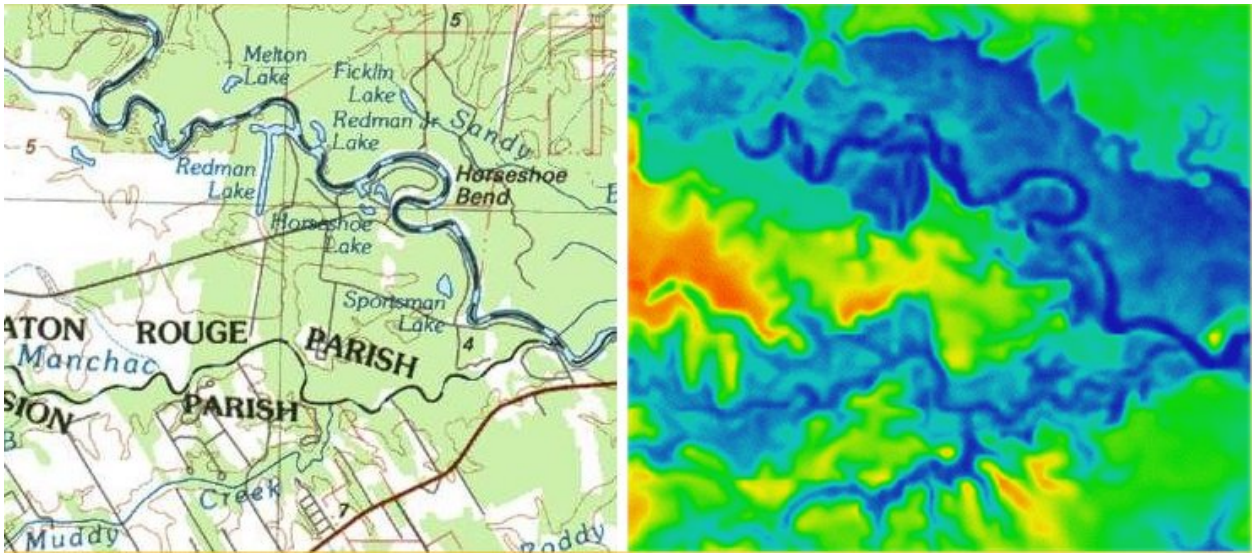


Figure 3: Digital elevation model with 10cm vertical accuracy can be used to define the floodplain in an area of very low relief. Note the detail not apparent in the standard 7.5 minute topographic map.

Wetland Impacts

The U.S. Army Corp of Engineers, Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Department of Agriculture Food Security Act of 1985, Emergency Wetland Resources Act of 1988, all have unique definitions of wetlands. Section 777.11(b) of 23 CFR states that the FHWA will use the definition adopted by the U.S. Army Corps of Engineers (33 CFR 323.2(c)) in its administration of the Section 404 permits: "*The term "wetlands" means those areas as that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.*" This definition of jurisdictional wetland requires the presence of hydric soils, hydrophytic vegetation, and periodic inundation or saturation. This definition is used by the Army Corps of Engineers (COE), U.S. Environmental Protection Agency (EPA), and other agencies using the Federal Manual (FICWD, 1989) or the COE Wetland Delineation Manual (USACE, 1987).

The COE issued a national delineation manual in 1987 and revisions in 1989 and 1991. Because of controversy regarding the revised manual, the National Academy of Sciences through a committee formed by the National Research Council was tasked with reassessing the adequacy and validity of wetland definitions. The committees report is expected to have a role in changes to the Federal wetland regulatory program in the near future. In the meantime, the FHWA recommends using the methodology described in reports FHWA-IP-82-23 and FHWA- IP-82-24, "A Method for Wetland Functional Assessment Volumes I and II" in wetlands delineation and analysis. The FHWA is also considering a hydrogeomorphic approach to wetlands assessment being developed by the COE (http://www.fhwa.dot.gov/environment/guidebook/vol1/doc14i.pdf).

When project alternatives will impact wetlands, the Draft EIS should present exhibits showing the distribution of wetlands in the project area in relation to alternatives and should describe the type, quality and function of each wetland. The EIS should address in sufficient detail the importance of the impacted wetland, and the severity of this impact. Merely listing the number of acres taken by alternatives is insufficient to determine the degree of impact on the wetland ecosystem. The function of the wetlands and their importance in the total wetland resources of the area must be considered. The analysis should show the project's effects (short- and long-term) on the stability and quality of the wetland(s): flood control capacity, shoreline anchorage potential, water pollution abatement capacity, fish and wildlife habitat value. Executive Order 11990 (http://www.fhwa.dot.gov/environment/guidebook/vol1/doc14u.pdf) mandates avoiding wetlands to the fullest extent possible. If the preferred alternative is located in wetlands, the EIS must document compliance with this Order. Creation of new wetlands is regulated by 23 CFR 777.

Current practice in wetland assessment is to deploy a field team consisting of a biologist and soil scientist. These individuals assess hydrology, soils and vegetation while boundary positions are identified and recorded with a differential GPS. The upper root zone or top 30 cm of wetland soils must be saturated for 12% of the annual growing season (~14 days) on more than 50% of growing seasons. These numbers vary slightly with geography. Vegetation and soil moisture needs to be documented almost on a daily basis during a critical period in the phenological cycle to determine if the 12% criterion is met. Wetland boundaries are delineated to an accuracy of

about 1 m and an areal accuracy of $1/100^{th}$ of an acre (40 m^2). Use of aerial photography is common, but is used less for interpretation than as a reference base map. Digital ortho-photographs may also used.

Application of remote sensing imagery for wetland assessment is a challenging problem. Water can be easily distinguished from adjacent terrain using multispectral imagery and synthetic aperture radar (SAR). Delineation requires 1 m resolution with 1 m positional accuracy. Presently, multispectral imagery is available at 2.5-4 m resolution. C band SAR data are presently available from satellite at 20 m resolution and X band SAR data are available from aircraft at 4 m resolution. Because water levels in a wetland fluctuate, the inundated area changes size and shape. The challenge is to acquire imagery early the growing season (preferably before complete canopy closure from leaf emergence) during maximum inundation. When wetland soils saturate from a slowly rising water table, there may not be any noticeable surface water. In this situation, multispectral remote sensing may not be of any utility. Significant progress has been made in past decade with regards to passive microwave remote sensing of soil moisture, but this technology is still too crude for application at the scale and sensitivity of this problem. In time, soil moisture remote sensing may become a significant resource. In some cases, wetlands are distinguished from the surrounding terrain on the basis of one to a few plant species. Even at 2.5 m resolution, imagery may be too coarse to characterize wetland vegetation. Where an assemblage of plant species characterize a wetland, multispectral or hyperspectral imagery at 2.5 to 4 m may be sufficient to aid in delineating the wetland. High resolution digital elevation data may also play a role in wetland delineation. If the boundary of a wetland can be delineated at several points, a digital elevation model can be used to estimate the perimeter ("water line") of the inundated area or area of saturated soil. The most probable application is some combination of the above methods. Although remote sensing will not replace the need for field validation, it may significantly reduce the number of man hours required.

Water Body Modification and Wildlife Impacts

For projects that require modifications of existing water bodies, the Draft EIS should contain exhibits and discussion identifying the location and extent of water body modifications (e.g., impoundment, relocation, channel deepening, filling, etc.) and the resulting wildlife impacts. Coordination efforts with appropriate Federal, State and local agencies should be documented, i.e., Fish and Wildlife Coordination Act of 1958. Remote sensing images could be used as reference base maps showing current location/shorelines of water bodies overlaid with proposed modifications. These maps could contain land cover and/or wildlife habitat information derived from multispectral imagery.

Threatened or Endangered Species Impacts

Threatened or endangered species are regulated by 50 CFR 402.12(c) and 16 USC 1536, Section 7 of the Endangered Species Act. A project is not eligible for federal funding if it does not comply with the Endangered Species Act or obtain an exemption. The lead agency must consult with the Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) to determine the presence of listed and proposed threatened or endangered species, and designated and proposed critical habitat in the proposed project area. The information regarding these species may be from a published list of species or critical habitat, a project-specific notification

of a list, or substantiated information from other credible sources. When a proposed species or a proposed critical habitat may be present in the proposed project area, an evaluation or, if appropriate, a biological assessment is made on the potential impacts to identify whether any such species or critical habitat are likely to be adversely affected by the project. This should be done in cooperation with the FWS and NMFS. In accordance with the Endangered Species Act, if the project is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat, the lead agency, in consultation with the FHWA, must confer with FWS and/or NMFS to attempt to resolve potential conflict. Also, if a listed species or a designated critical habitat may be present in the proposed project area, a biological assessment must be prepared to identify any such species or habitat which are likely to be adversely affected. The biological assessment must summarize data regarding, among other things, the species distribution, habitat needs, and other biological requirements; the affected areas, etc. The Draft EIS should include exhibits showing the location of the affected species or habitat.

Except for shallow water estuaries and coastal zones, remote sensing of marine habitat is limited. On the other hand, remote sensing of terrestrial habitats holds much promise. Where habitat can be identified as a biome or assemblage of vegetation species, multispectral remote sensing has significant potential. Remote sensing could then be used to map critical habitat and identify habitat continuity and wildlife movement corridors or potential habitat fragmentation as a result of proposed alternatives. Remote sensing will not eliminate the need for on-site verification, but may expedite the assessment process.

Historic and Archeological Preservation

In accordance with 36 CFR 800.4, the EIS should demonstrate that historic and archeological resources have been identified and evaluated. The information required for historic structures should be sufficient to determine their significance and eligibility for the National Register of Historic Places. The information required for archeological resources should be sufficient to identify whether each warrants preservation in place or whether it is important chiefly because of what can be learned by data recovery. Proposed use of land from an historic resource on or eligible for the National Register and all archeological sites also on or eligible for the Register and which warrant preservation in place will normally require an evaluation and approval under Section 49(f) of the DOT Act. Effort needed to evaluate and identify these resources will vary from project to project as determined by the FHWA.

All too often, the archeological impacts are dispensed with by an expert based on prior knowledge of the distribution of historical sites. In areas with prior expectations about the presence of sites of archeological significance, aerial photographs and remote sensing are used for search and analysis. High resolution imagery fused with DEM data could potentially be used to identify Native American ceremonial mounds and canals used to manage water, early American breastworks, etc. Remote sensing cannot replace site surveys, but can reduce the number of man-hours involved in on-site verification.

Relocation Impacts

When proposed actions require displacing existing structures and facilities, the EIS is required to estimate and report the number of displaced households, businesses and farms, and identify

affected neighborhoods and public facilities. In addition, the EIS must identify available relocation sites, such as the availability of housing comparable to that of the displaced families, identify sites available in the area to which affected businesses can relocate. Relocation must be in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. Much of this information would be obtained from socio-economic databases. With the recent development of very high resolution multispectral remote sensors, it is feasible that imagery can be processed to distinguish between single-family homes, multi-family homes and businesses (Fig. 4). Although the technique may not be 100 percent accurate, it may reduce the amount of time required for validation on the ground. These techniques may also be used to identify comparable housing, but would not be able to determine their availability. It is likely that a combination of imagery and socio-economic data may be the most streamlined approach.

Figure 4: High resolution multispectral imagery like these 10 m data can be used to identify single and multifamily dwellings. Digital processing techniques can be employed to quantify the number of such structures.

Water Quality Impacts

The Draft EIS must describe ambient conditions of streams and water bodies that are likely to be impacted by the proposed project. Under normal circumstances, existing data may be used. Use of water quality data spanning several years is encouraged to reflect trends. The EPA, under the Federal Clean Water Act, may provide assistance. Coordination with Federal, State and local agencies responsible for water quality should be included in the EIS. Three FHWA documents provide procedures for estimating pollutant loading from highway runoff and are helpful in determining potential impacts and appropriate mitigation measures. Locations where roadway runoff or other nonpoint source pollution may have an adverse impact on sensitive water resources should be identified. Principal or sole-source aquifers (defined and protected under Section 1424(e) of the Safe Drinking Water Act) impacted by the project should be coordinated with the EPA. The critical aquifer protection area should also be protected. EPA has regulatory authority and must approve any design that cannot avoid the aquifer area. Wellhead protection areas must be identified and avoided in accordance with the 1986 Amendments to the Safe Drinking Water Act. Coordination with the State agency responsible for the protection plan is recommended.

Remote sensing cannot be used to assess water chemistry directly. It can, however, be used to detect changes in temperature, water productivity and turbidity as a function of chemical changes. Because vegetation and water have unique spectral signatures, multispectral imagery can be used to monitor changes in aquatic vegetation growth. Remote sensing can also be used to monitor changes in turbidity due to changes in erosion within the watershed and sedimentation in water bodies. The timeliness of remote sensing, may be the greatest impediment in this application.

Air Quality Impacts

Air quality impacts are separated into mesoscale and microscale concerns. Mesoscale concerns include ozone, hydrocarbons, nitrogen oxide, whereas microscale concerns focus on carbon monoxide. Proposed projects should be described in the EIS in relation to the State Implementation Plan (SIP) for air quality. Either the project is or is not in an area that has transportation control measures in the SIP or the project is or is not in an air quality attainment area. An analysis of CO is necessary if it is judged on the basis of previous analyses for similar projects or published data that the contribution of the project will cause the area to exceed the 1- or 8- hour standards. Thus, measurements of CO are required.

Aerosols are a significant component of air pollution. Remote sensing of aerosols in the atmosphere is a mature science and continues to improve. Most of these measurements, however, focus on the upper troposphere and stratosphere and thus, contribute little to our understanding of urban air quality. Remote sensing of chemical constituents of air pollution is a new and emerging area. In most cases, the space-time dimensionality of aircraft- or satellite-based remote sensing is inconsistent with air quality measurements. However, recent research suggests that continuously monitoring ground-based sensor systems may provide valuable air quality information.

Acceptance and Implementation of Remote Sensing

Some of man's best inventions have failed to get embraced by the public based on their merits alone. Conversely, some of the most useless widgets have gained at least temporary success because of an outstanding marketing strategy. Although remote sensing seems to hold great potential for streamlining some areas of environmental assessment in transportation, there are numerous impediments that must be addressed before it will be widely accepted as an alternative to existing techniques. For example, the FHWA has in some cases define an assessment methodology. Because remote sensing is not a direct substitute for existing measurements, methods may need to be altered to take full advantage of a different type of information. There may be inertia among EIS preparers or stakeholders in voluntarily altering their approach. After all "that's the way it has always been done." The decision to embrace remote sensing assumes that the data provided by remote sensing is in some way better than existing information, but how do we define "better" information? Who must we convince that we may have a better widget? In the following text, we attempt to identify some of the issues that must be addressed to enhance the acceptance and implementation of remote sensing.

Assessment Methodology

The methodology used in conducting an environmental assessment dictates what data, information, and analyses are required. The adequacy of the conclusions is a direct function of how well the methodology employed meets professional and scientific standards. CEQ regulations require the methodology used in EISs to have professional and scientific integrity and to identify sources used in forming a basis for the conclusions (40 CFR §1502.24). Several factors affect the choice of methodology for analyzing a specific topic (Kreske, 1996):

1. How appropriate the methodology is for the topic under analysis
2. How well-accepted the methodology is in the particular discipline or scientific community
3. How much information is available about the proposed action or about the environmental topic in the area of study
4. How much time, money, or other resources are available to use the methodology under consideration

Trade-offs among these factors is required to arrive at a preferred method. The courts have determined that the "best" method, be it less costly or more scientifically sound, does not have to be used in an EIS (Kreske, 1996). The criteria for determining the best method should be based on whether the information is necessary to allow the decision-maker to make an informed decision. The purpose of EISs is not to generate scientific or technical data in spite of how useful it may be, but to generate informed decisions by a lead agency for a proposed action.

The courts have determined that the "best" method does not have to be used in an EIS.

EIS authors should describe the methods used in each environmental subject area so that this information is available for technical analysis as part of the review process. This documentation is even more important if the EIS is more complex and involved. Whereas authors of EISs often describe the methods utilized in conducting the assessment, they neglect to explain why the particular method was used, what limitations affected the methodology, and why other methods were not used. This omission often leads to confusion and raises concern of reviewers of Draft EISs regarding the rationale behind the author's analysis. Furthermore, the reviewer may disagree with the choice of method due to their lack of understanding of *a priori* limitations. Thus, EIS authors must provide a thorough explanation of the rationale for the appropriateness of various methods and discuss limitations of each to avoid concerns by reviewers.

Assessment Data

The data used in an assessment undergoes the same scrutiny for scientific and professional integrity, as does the methodology used in obtaining and analyzing data. Data sources should be referenced in a manner consistent with the professional or scientific discipline. Although there are no prescribed data sets to be used in an assessment, they should possess the following basic attributes: relevant, current enough to be useful, reputable or from a credible source, and in a usable format. Of these, obtaining usable data is often the most problematic. All too often, existing data sets are misrepresented and turn out to be something other than what they were represented or no one has any confidence in these data. Most data used in EISs comes from established sources--the most common of these are state and federal natural resource agencies and libraries. More recently, data clearinghouses have been a source of digital geospatial data.

Sometimes a reviewing agency will reject an EIS on the basis that the EIS does not present enough data from which to agree or disagree with its findings. EISs are not required to have all data that any reviewer might say is necessary (Kreske, 1996). An EIS is only required to have sufficient data to make a decision on the proposed action. On the other hand, an EIS is required to disclose any gaps in information relevant to the proposed action and discuss what affect the missing data may have on the analyses. Also, exclusion of any data that may be familiar to reviewers should be explained to avert reviewer concerns.

In most cases, there is a preconceived idea among the EIS prepares and the regional FHWA as to what constitutes "best available data." There is, however, no official definition of best available data—this is principally a byproduct of experience. Consequently, this is rarely an issue for dispute. This does not imply, however, that there may not be a better way of acquiring or analyzing necessary information, but through years of experience, EIS preparers and lead agencies have become familiar with certain data sets and have grown accustomed to their application for various assessments. Behind many of the data sets used in environmental assessments are federal agencies that developed each of the data sets. Information from remote sensing must be in some way "better" than traditional sources of information before it will be embraced by planners, decision-makers, and other members of the transportation community. How then do we define data or information as “better”? Who makes the decision as to what is better? If we consider remote sensing as a marketable technology, then we can consider the consumer of this technology as the stakeholder. Who are they? What are their needs? On what basis would these stakeholders define better data?

Defining "better" data and information sources is one contribution to improving the EIS process. The following is a partial list of criteria that constitute better data relative to existing data:

1. previously unavailable
2. available more frequently or on-demand
3. easier to acquire or apply
4. more complete
5. more precise
6. more detailed or provides better discrimination
7. more spatially, topologically, or thematically accurate
8. greater integrity and/or consistency
9. known and/or quantifiable errors
10. from reproducible method with less human error or bias
11. readily adaptable to existing processing
12. user has greater trust or confidence
13. from a more reliable source
14. serves more than one need
15. more user friendly
16. associated with documentation and training
17. heritage of successful application
18. more closely related to existing performance indicators

Decisions about what is the best data to use must be made in light of the application of the data. Although a sledgehammer is more effective at driving nails than a tack hammer, it is clearly not the right tool to drive carpet tacks. Likewise, the choice of data should be consistent with appropriate performance indicators. Continuing the analogy, the tack hammer is the obvious tool

of choice when the performance indicator is a well-laid carpet, not effective nailing. Data acquired for a one-time federal inventory of regional- or national-scale resources are not appropriate to use to assess local-scale issues. Often, however, data of incompatible scale are the only information that is available on which to base a decision. In the absence of something better, it may have been done that way for a long time. Utilizing a new data source requires identifying appropriate stakeholders and end users and educating them on the virtues of these alternative sources.

End Users and Stakeholders

Remote sensing has been described as a tool in search of a challenge. Implementation of remote sensing as a supplemental or alternative source of information for environmental assessment requires that we identify the stakeholders for this technology for it is these entities that need to be educated about the benefits of remote sensing. The fact that remote sensing has only been exploited in a limited manner for environmental assessment in transportation is due in part to this failure.

End users are the entities that apply remote sensing for assessment. To them, it is one of many assessment tools like a topographic map, Geographic Information System, theodolite, or Secchi disk. Consulting firms who perform environmental assessments under contract with the lead agency represent an end user. End users do not have a vested interest in remote sensing as a technology. They simply apply a proven technology for reasons of efficiency or competitiveness at the recommendation of the lead agency.

Stakeholders on the other hand, have a vested interested in remote sensing as a technology insofar as it can make measurements and discriminate among features accurately in support of or in lieu of other measurements. This may be on a case-by case basis or through development of a product that would be valuable to multiple users. Federal and State agencies that have a mandate to manage and/or regulate natural resources would be one example of stakeholders. These agencies are often responsible for mapping or monitoring the state of resources, such as forests, rangeland, wetlands, parks, water quality, etc. These agencies would have a vested interest in remote sensing applications that would permit them to update or revise their maps more efficiently or more frequently thereby enabling them to better manage resources under their jurisdiction. Likewise, agencies involved in planning, such as metropolitan planning organizations, are stakeholders whereby remote sensing may provide them with a more up to date synoptic view of a region of interest or more detailed and current information about assets.

The lead agency that must approve or reject an EIS is also a stakeholder. The lead agency may advocate using remote sensing as part of the EIS if they feel that it would allow them to make a more informed decision about a proposed action. The lead agency itself may also be an end user if it conducts some of the assessment using its own personnel. The agency requiring the EIS is also a stakeholder; this agency may or may not also be the lead agency. Remote sensing contributes to streamlining; therefore, the agency responsible for the EIS receives the Draft EIS in a timelier manner. In some cases, the distinction between stakeholders and end users is unclear as a single entity may serve multiple roles.

Regulations and Accuracy Standards

EISs are prepared in the context of environmental laws and regulations. These regulations define the "rules" by which EISs are prepared and regulatory authorities routinely interpret and enforce these rules. Such rules place restrictions on what is defined as acceptable methods. Having a clear understanding of the regulations, data accuracy standards, and what latitude is permitted is essential to defining potential remote sensing applications.

Despite broad statements in NEPA, unlike some environmental laws, NEPA has no "teeth"; that is, environmental considerations do not have to be elevated above other considerations; and there are no civil or punitive penalties, such as fines or imprisonment, for not complying with the law (Kreske, 1996). (Recently, however, the US DOT has threatened to withhold federal highway funds from states with metropolitan areas that fail to comply with EPA's ozone standard.) The CEQ has regulations for implementing NEPA (Council on Environmental Quality Regulations on Implementing NEPA, 40 CFR 1500-1508). CEQ has also issued several nonregulatory guidance publications on NEPA: Questions and Answers about the NEPA Regulations (1981), Scoping Guidance (1981), Guidance Regarding NEPA Regulations (1983). The FHWA is the primary organization responsible for certifying that construction projects are in accordance with all applicable statutes, although it has little regulatory authority. The FHWA's Guidance on Preparing Environmental Documents is not regulatory. Instead, the FHWA makes recommendations as to which agencies should be consulted for interpretation of various regulations and encourages coordination among agencies at all levels of government. Regulatory authority resides with the agencies that manage the resources, issue permits and licenses, are involved in construction, and grant funds. For example, the EPA has regulatory authority over aquifer protection and is responsible for approving any design that cannot avoid the aquifer area. The US DOT requires the COE to license construction activities associated with wetlands. Approval from the COE signifies that all applicable regulations have been addressed regarding wetland issues.

Many agencies like the USDA NRCS or the FWS that manage resources have developed national maps of these resources. A clear understanding of the accuracy standards to which the original information was obtained is required in order to identify applications where remote sensing information can supplement, replicate, or improve upon the information contained in these maps. NEPA and the FHWA do not mandate specific minimum data tolerance requirements for environmental assessment. Assessment activities are evaluated on a case-by-case basis by the engineers in charge. "The level of analysis should be sufficient to adequately identify the impacts and appropriate mitigation measures…" (FHWA, 1987). Likewise, for environmental assessment, the COE does not specify accuracy and tolerance requirements for data acquisition. The COE sees no value in requiring rather arbitrary tolerances for dynamic environmental phenomena. The COE allows engineers to choose acquisition techniques consistent with the project's requirements. The presence of endangered species, political influences, and various other factors affect the level of accuracy that is required from site to site. On the other hand, for construction projects, the COE publishes a tolerance guideline used for determining what level of accuracy is required. The COE requires tolerance ranges for on-site GPS measurements of 2-3 cm for elevation accuracy and 1-2 cm for lateral positional accuracy. For floodplain mapping, FEMA has specified a standard that provides for up to a 1-foot increase in flood stages when designating a floodway or evaluating an encroachment where no floodway is designated.

Adopting Innovation

A fundamental challenge of a new application is to overcome the inertia to change and adopt innovation. Inertia manifests itself for many reasons: *Skepticism*—can remote sensing do the job? Does remote sensing provide the information I need? Does it meet regulatory requirements for accuracy? Do metrics for existing data readily transfer to remotely sensed information? *Cost*—how does remotely sensed information compare with traditional sources that may be available from a national data clearinghouse or library? *New*—methods become entrenched in society. "We've been doing this way for as long as I can remember." There is a legacy within the organization. MPO's have been using aerial photography for years. There was tremendous resistance to acceptance of GIS in the late 1980's and early 1990's. Remote sensing requires an even higher degree of technical expertise. Many maps are used as the best available source of information and considered the *de facto* standard. Because of the immensity of Federal and State mapping programs, these maps are produced every couple of decades and updated on perhaps a decadal time scale. Although, they may not depict the most current information, they are entrenched in society. Few agencies have the knowledge or latitude to change their procedures to attempt different approaches. *Unfamiliar*—what data to do I acquire? Where do I get it? How do I specify what I need? How do I choose between two sources of information? How do I process these data? How do I interpret the information? It just doesn't "feel" right! Lack of familiarity with a new way of conducting an assessment may result in confusion and impede acceptance. *Resources*—What do I need to use remote sensing data? How many man-hours will it require? What software do I need? Can I still use my existing computers? These are just some of the reasons that limit diffusion of an innovation like remote sensing into the environmental assessment process associated with transportation.

The speed with which an innovation is adopted is dependent on five factors: Relative advantage, Compatibility, Complexity, Trialability, and Observability (Rogers, 1983). *Relative advantage* is the extent to which the innovation is perceived to be better than the current practice. The perceived positives must outweigh the negatives. EIS preparers and stakeholders must be convinced that remote sensing offers "better" data, as it was previously defined, and this in turn can lead to better, more informed decision-making. This puts the onus on those developing remote sensing applications to educate stakeholders about what remote sensing has to offer so that he/she will consider its application as an additional source of information to meet existing requirements. Remote sensing should be viewed as a supplement to or enhancement of existing information, not as a replacement. The advantages of remote sensing in meeting agency performance criteria should also be presented. Even without improvements in decision making, remote sensing may be a more cost effective approach to assessment in some instances. For small-scale projects, remote sensing may be too costly at this time, but for large-scale projects, remote sensing techniques can offer significant cost savings compared to conventional on-site measurements. In a recent demonstration study, use of remote sensing contributed to a significant reduction in the cost of the environmental assessment (Jones, R., pers. comm., Green, 2001).

Compatibility is the degree to which the innovation is perceived to be consistent with current values, past experiences, and priority of needs. Remote sensing should be perceived as very compatible with existing practices. At a high level, remote sensing is just another source of geospatial information used for environmental assessment upon which informed decisions are made. Its uniqueness is in the details. At a low level, the application of remote sensing will

result in slight changes towards a more streamlined workflow. However, because remote sensing measurements may not be a one to one replacement for an existing measurement, but an alternative, a paradigm shift in the approach to assessment may be required.

Complexity is the degree to which the innovation is perceived to be difficult to understand or use. As with any technical discipline, there is an associated vocabulary that is unfamiliar to the layperson. Those in the remote sensing field need to be conscientious about using terminology that is unfamiliar to persons from other backgrounds so as not to give the false impression that remote sensing is an insurmountable technical challenge. It should be acknowledged that some aspects of remote sensing are indeed technologically difficult; a distinction should be made between the development of remote sensing application products and the interpretation of these products for assessment purposes. Developing extraction techniques and application products is technologically demanding requiring a trained image analyst, but less skill and training are required to interpret these products in the context of an assessment.

Trialability is the extent to which an individual or agency can try out one idea on a limited basis with the option of returning to previous practices. Because remote sensing requires a certain level of expertise and specialized computer software, trialability is being executed in conjunction with the NCRST-E. The NCRST-E is teaming with stakeholders in government and industry to conduct demonstration projects thereby allowing agencies an opportunity to learn more about remote sensing and gain greater familiarity with how it may impact traditional workflows. *Observability* is the extent to which the results of an innovation are visible to others. An innovation with highly visible, beneficial results is more rapidly diffused. To this extent the NCRST-E has developed a web site to distribute information and educational materials and communicate results of various projects. Consortium personnel are also involved in communicating consortium activities at professional workshops and conferences. Vendors and government agencies that have independent results are encouraged to share their successes with others. Some of this information is presented in professional journals, and trade magazines.

Conclusions

One of the strategic goals of the Federal Highway Administration (FHWA) is to "protect and enhance communities and the natural environment affected by transportation." Environmental protection is accomplished through Environmental Assessments and Environmental Impact Statements that seek to prevent adverse environmental effects from taking place rather than mitigating problems caused by past activities or practices. EISs are conducted in the context of an overall decision-making process that is inexact and fluid. Despite the fact that EISs are conducted in accordance with Executive Orders, environmental laws, and regulations, the process is laced with subjective components, such as "significant impact," "best available data," and loosely defined accuracy requirements. Although the rationale for EISs is environmental protection, they are not in and of themselves regulatory. The cost to the environment is weighed against the benefits of the proposed project. EISs are simply a source of information on which to base informed decisions.

For the most part, there are no hard and fast rules or requirements in EIS preparation. The laws and regulations tend to address the process, not specific procedures. The courts have determined that the best method does not even have to be used. The information used, however, should have

sufficient scientific and analytical substance to provide a basis for evaluating the comparative merits of the alternatives, and should contain sufficient supporting information or results of analyses to establish the reasonableness of the conclusions on impacts. Decisions regarding the adequacy of certain data or methods are up to the discretion of the engineer overseeing the assessment.

Although the data issue is a very small part of an overall streamlining effort, the U.S. Department of Transportation seeks to determine if remote sensing can contribute to streamlining the environmental assessment process. The framework noted above contains significant latitude for the application of remote sensing as a supplemental or alternative source of environmental information associated with transportation development. Of the 25 environmental impact areas the FHWA recommends addressing in an EIS, 13 are good candidates for remote sensing in some capacity. In many cases, current "off-the-shelf" techniques can be utilized directly. In other cases, the assessment requirements dictate using newer data sets for which experience is limited or for which image processing techniques need to be refined or developed. However, these issues do not appear to be insurmountable obstacles.

Perhaps the greatest challenge is in obtaining broad utilization and acceptance of remotely sensed imagery. Skepticism, unfamiliarity, cost, capital equipment and human resource needs are just of few of the anticipated impediments that must be addressed before broad utilization and acceptance can be achieved. In some cases, these impediments are real, but in many instances, they are fairly trivial. The NCRST-E is appropriately postured to provide the research and development and outreach services needed to raise remote sensing to the forefront of environmental assessment in transportation. The lessons learned over the last fifteen years with the implementation of GIS and GPS technology in transportation planning and engineering should be applied to remote sensing technology as well. A broad array of demonstration projects are needed, not simply to provide examples of remote sensing capabilities, but to engage the stakeholders in the process, assess the costs and benefits, and demonstrate overall the intrinsic value in accepting change.

References

Barnes, S., ed., 2001, Elevation: the XYZs of active airborne sensing, A supplement to Geospatial Solutions and GPS World, Sept., 34 p.

Brecher, A., 1999, Summary of the DOT National Forum on Remote Sensing Applications to Transportation, DOT, Transportation Science and Technology, Research and Engineering, http://scitech.dot.gov/reeng/sensmsrm/rmtsense/sbrsmstr.html

FICWD (Federal Interagency Committee for Wetlands Delineation), 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*, U.S. Government Printing Office, Washington, D.C., 76 pp.

FHWA, 1982a, Guidelines for the evaluations of encroachments on floodplains, http://www.fhwa.dot.gov/environment/guidebook/vol1/doc6e.pdf

FHWA, 1982b, Procedures for coordinating highway encroachments on floodplains with the Federal Emergency Management Agency, http://www.fhwa.dot.gov/environment/guidebook/vol1/doc6d.pdf

FHWA, 1986a, Design standards for highways in National Flood Insurance Program mapped floodplains, http://www.fhwa.dot.gov/environment/guidebook/vol1/doc6c.pdf

FHWA, 1986b, Guidance for implementing the one-foot standard for encroachments on NFIP floodplains, http://www.fhwa.dot.gov/environment/guidebook/vol1/doc6b.pdf

FHWA, 1987, Guidance for preparing and processing environmental and section 4(F) documents, FHWA Technical Advisory T 6640.8A, U.S. Dept. of Trans., Federal Highway Administration, 51 p.

FHWA, 2001, Evaluating the performance of environmental streamlining: development of a NEPA baseline for measuring continuous performance, U.S. Dept. of Trans., Federal Highway Administration, http://www.fhwa.dot.gov/environment/strmlng/baseline

Flood, M., and Gutelius, B., 1997, Commercial implications of topographic terrain mapping using scanning airborne laser radar, Photogramm. Eng. Rem. Sensing, 63, 327.

FWS, 1983, Coastal Barriers Resource Act, Advisory Guidelines, Federal Register, v. 48, no. 195. http://www.fhwa.dot.gov/environment/guidebook/vol1/doc2c.pdf

Green, T., 2001, Don't scare the fish: remote sensing helps Oregon map around salmon , trout, Roads and Bridges, v. 39, no. 5, Scranton Gillette Communications.

Knight, J., 1980, Seventies into eighties, in The New Environmental Handbook, Garrett DeBell, editor, Friends of the Earth, San Francisco, CA.

Kreske, D.L., 1996, Environmental impact statements: a practical guide for agencies, citizens, and consultants, John Wiley & Sons, Inc., New York, 480 p.

Maune, D., ed., 2001, *Digital Elevation Model Technologies and Applications: The DEM Users Manual*, American Society of Photogrammetry and Remote Sensing, 540 pp.

Rogers, E., 1983, *Diffusion of Innovations*, 3rd Edition, The Free Press, N.Y.

Reinke, D. C., and Swartz, L.L., eds., 1999, The NEPA Reference Guide, Batelle Press, Columbus, OH, 267 p.

USACE (U.S. Army Corp of Engineers), 1987, *Wetlands Delineation Manual*, Tech. Rept. Y-87-1, Department of the Army, Washington, D.C.

Interviewed Industry Professionals

Bennett, Tom
Federal Aviation Administration

Bush, Dr. Al
Chief of Engineering Systems and Materials Division
Army Corps of Engineers

Carpenter, Bobby
Environmental Engineer
The CADD/GIS Technology Center
USAE ERDC - Army Corps of Engineers

Crim, Bob
State Project Development Engineer
Florida DOT – Environmental Management Office

Doyle, Fred
Vice President
Space Imaging

Gilmore, William D.
Manager of the Project Development and Environmental Analysis Branch
Project Development and Environmental Analysis
NC Dept. of Transportation

Jones, Rick
Director of Regional Services
Space Imaging

Moyers, Bill
State Roadway Construction Engineer
NC DOT

Orr, Dr. Wilson
Director, NASA Sustainability and Global Change Program
Prescott College

Pangburn, Timothy
Chief of Remote Sensing, GIS, and Water Resources
Cold Regions Research Center
Army Corps of Engineers

Rentch, Ruth
Environmental Protection Specialist
FHWA - Office of NEPA Facilitation

West, Wade
Research Civil Engineer
Environmental Sensing and Laboratory Branch – Waterways Experiment Station
Army Corps of Engineers